Meteor Scatter Communications at VHF

Introduction

(T*he full text of this presentation is available at* ms.KR8L.us.)

Tonight we are going to talk about how, as Radio Amateurs, we can use the ionization trails left behind by high speed meteors to extend our VHF communication range out to distances of hundreds of miles. Disclaimer: this is not a "rag chew" mode, but a technique that allows for very brief contacts for such purposes as making contest exchanges or collecting Grid Squares.

Because this is a somewhat unusual and complicated subject, rather than jumping right into a "how to" presentation, I want to start by reviewing some basic concepts.

"Normal" VHF Propagation

We normally think of VHF communications as being limited to "line of sight." That is, in order to communicate, if I stand next to my antenna I should be able to see your antenna (although I might need a telescope if the distance is great, or X-ray vision to see through minor obstacles such as trees, etc.). If your antenna is so far away that it is beyond the Earth's horizon or if it is behind large obstructions such as a mountain or several tall buildings, then we usually assume that we won't be able to communicate. In fact, there are several propagation modes that Radio Amateurs use to extend their VHF and UHF communications range out to several hundred or perhaps over a thousand miles. Meteor Scatter is one of those modes, and that is what we are going to talk about tonight.

Meteors

The Earth encounters millions of meteors each day. Most of these are the size of dust particles, and are of no concern to us. A few are large enough to produce a spectacular visual display, and a very few are large enough to reach the surface of the Earth before they burn up. The meteors that are of interest of us for communications purposes are about the size of a grain of rice, or perhaps a green pea. Of these, the Earth encounters relatively very few each hour.

Ionospheric Propagation

You are probably familiar with the idea that ionization in the upper layers of the atmosphere (the ionosphere) makes it possible for HF signals to reach around the globe. Air molecules in what is known as the "F Layer" of the atmosphere (120 to 250 miles in altitude) are ionized by ultraviolet and X-radiation from the Sun, and this creates a sort of mirror that reflects HF radio waves back to the earth so that they can travel beyond the horizon. However, because the atmosphere is very thin at this altitude, the ionization is not dense enough to reflect radio frequencies at VHF and above.

Ionization can also be caused by the energy of very high speed meteors as they pass through the atmosphere. As these meteors pass through the what is known as the "E Layer" at about 60 miles in altitude they create long trails of very dense ionization. This ionization is so dense that it can reflect radio signals at frequencies as high as 50, 144, and 222 MHz, and to a limited extent 432 MHz.

Because the atmosphere is relatively dense at this altitude, the ionization trails recombine fairly quickly, so each individual trail is available for communication for a very brief time: anywhere from a fraction of a second to several seconds (or possibly a minute or more in extreme cases). In addition, only a very few of our grain of rice-sized meteors -- perhaps five to ten per hour -- are of the appropriate orientation and location so as to support communication between any two particular stations on the Earth. As you can imagine, all this makes meteor scatter communications very challenging!

Equipment

Meteor scatter communications do not require particularly exotic equipment, but there are some basic needs that, if met, will increase the chances of success. I will give examples for 2 meters since this is a popular band for meteor scatter work. Starting at the top, I would recommend a moderately sized Yagi antenna of between seven and 12 elements, horizontally polarized (which is the standard for all *weak signal* work). A low noise receiving preamplifier (say, 15 to 20 dB) is very desirable, preferable mounted at the antenna, but placement at the shack end of the feedline is an alternative. Low loss feedline should be used if at all possible (say, 2.5 dB loss per 100 ft at 400 MHz). A power level of 100 to 150 watts is desirable, so a small brick amplifier should be used unless the transceiver is capable of this level of output. Finally, you will need a transceiver capable of SSB operation. Again, these numbers are appropriate for 2 meters. For 6 meters a smaller antenna and less power can be used and for 1.35 meters and above correspondingly larger antennas and more power are needed because the efficiency of the ionization with regard to reflecting RF energy decreases with increasing frequency. Above 70 centimeters meteor scatter communications do not appear to be practicable. It should also be noted that the lower the frequency, the greater the length of time that the ionization trail will support communication before it recombines.

Since most meteor scatter work now takes place using digital modes, you will also need a computer, sound card, and transceiver-to-sound card interface device. This is the same equipment that was described by Bruce, KS4V, when he discussed radio teletype (RTTY) at the March 2007 PARA meeting.

Procedures

What Constitutes a Contact?

Before we can talk about how to make a contact using meteor scatter, we need to talk briefly about what is it that makes up a valid contact. For the purpose of VHF work -- and this holds true for HF also -- a valid contact occurs when both stations send and receive (1) both callsigns, (2) at least one unique piece of information such as a signal report, and (3) acknowledgment of receipt. Consider, for example, a typical contest exchange on HF:

Station A: CQ CONTEST AB4IQ
Station B: AB4IQ KR8L
Station A: KR8L 59
Station B: ROGER 59
Station A: ROGER 73 CQ CONTEST AB4IQ

If you study this for a moment you will see that this very brief exchange contains everything needed to count as a "valid contact."

Procedures -- SSB

Although digital operation is the norm for meteor scatter these days, I would first like to describe how we did meteor scatter using SSB for many years, since this will help to understand how a typical QSO is structured. These procedures have carried over to the digital modes almost unchanged. Many (probably the majority) of meteor scatter QSOs are scheduled, that is, the time and frequency are agreed upon in advance -- in many cases just a few minutes in advance. We used to do this by means such as a telephone call or by meeting on a 75 meter coordination frequency. Now it is typically done using E-mail, or by logging on to a coordination Web site. More about this later.

Besides agreeing on a time and frequency, both operators would agree on a "sequence." Typically, each operator would transmit for 15 seconds and then listen for 15 seconds, so it was necessary to decide who took the first and third quarter of each minute and who took the second and fourth (by convention, "west goes first"). It was also necessary to ensure that both station clocks were closely synchronized with WWV.

To start, both operators would send both callsigns: KS4V KR8L KS4V KR8L ... During the receive portion of the sequence you might not hear anything for many minutes, or perhaps many tens of minutes. Eventually you might hear a fragment: ... 8L KS4 ... At some point you might hear both callsigns. If you heard both callsigns you would start sending a signal report in addition to both callsigns. For brevity, only three signal reports were used: S1 (weak) through S3 (strong). Thus, after hearing both callsigns successfully, I would send: KS4V KR8L S2 KS4V KR8L S2 ... If the other station managed to copy all of this, he would immediately know that I had copied both callsigns, because that is the requirement for sending a signal report. At this point he could stop sending callsigns (except as required for station identification) and (because he now had received both callsigns) could start sending a signal report acknowledging both callsigns and also a "roger" acknowledging receipt of my signal report: ROGER S2 ROGER S2 ROGER S2 ROGER S2 ROGERS2 ... If I managed to copy this, I would know that he had received both calls and my signal report, and I could start sending nothing but rogers: ROGER ROGER ROGER ROGER ... At this point we would be essentially finished, since both stations had sent (1) both callsigns, (2) at least one unique piece of information such as a signal report, and (3) acknowledgment of receipt. It was common practice, however, that upon hearing my rogers the other station would send 73 73 73 73 73 73 ... Once I had received that I might have come back on the coordination frequency to announce something such as: "KS4V THIS IS KR8L I HAVE YOUR 73s, THANKS FOR THE QSO."

Whew! That was a lot of work!

Procedures -- Digital

Back in 2001, a very fine gentleman named Dr. Joe Taylor, K1JT, developed a computer program for performing meteor scatter work using digital communications. (By the way, Joe is a Nobel Prize-winning astrophysicist and recently retired Dean of Faculty at Princeton University. The work that won the Nobel Prize was related to the use of binary pulsars to verify a portion of Einstein's General Theory of Relativity as it relates to the propagation of gravity waves through space. A summary of Joe's work can be found on the Nobel Web site.) Joe's computer program, called WSJT (meaning Weak Signal Communication by K1JT), was enthusiastically adopted by the meteor scatter community, and he has continued to develop and update the program and expanded its usefulness to other areas such as moonbounce (EME) and very weak signal terrestrial work.

The procedures for meteor scatter using WSJT are very similar to those using voice. Transmit sequences of 30 seconds on and 30 seconds off are typical, and a numerical system of signal reporting is used to convey both duration and intensity of pings received. (Duration is rated one through five, and Strength is rated as six through nine. A report for a typical short ping might be "27.") Also, other exchanges, such as grid squares, are sometimes used instead of signal reports, especially for contests. The WSJT program automatically manages the receive and transmit sequence, but the station operator is the one who decides when and if he has received the correct information (as displayed on his computer screen) and what message to send at what point in the contact (e.g., callsigns, signal reports, and/or rogers). The program performs the drudgery of sending the same information over and over, and through sophisticated digital signal processing techniques makes it possible to decode signals at a level many dB below that required to hear (not just understand, but actually hear) a voice signal.

Scheduling of contacts is now much more sophisticated, typically using the Internet. The most popular site is probably Ping Jockey Central. (Meteor scatter operators are traditionally known as "ping jockeys," by the way.) If you visit Ping Jockey Central and watch the screen for a while (the page automatically updates every minute) you will probably see quite a bit of activity and can begin to get an idea for the scheduling process, frequencies used, etc. One way to get familiar with meteor scatter is to watch for someone running a schedule and transmitting in your general direction and then listening for his pings.

One important thing to note is that once two stations begin a "run" (as the QSO process is called), it is absolutely inappropriate for them to exchange any information pertaining to the QSO via the Internet or any other means (such as "I am receiving your signal report now"). Doing so will invalidate the QSO, and they will have to restart from the beginning or quit for now and try at another time.

So, Where and When Do I Find the Meteors?

The best time to find the most meteors is during one of the known showers when rates as high as 100 per hour or more may be encountered. The dates of these showers are well known and published, but there is still more to consider. Each shower appears when viewed from the Earth to be coming from a known point in the sky, called the "radiant," (typically named for the particular constellation in which the radiant appears) and the radiant must be above your horizon for the shower to be visible. Next, the apparent direction of flight of the shower varies from shower to shower and with the time of day. This determines what will be the most favorable propagation direction. Finally, the time of day is important: during the late night and early morning your part of the Earth is facing in the direction that the Earth is moving in its orbit around the Sun, so the relative velocity of the meteors is highest, which gives more persistent and stronger ionization trails. In contrast, late in the afternoon and early evening you location is on the "back side" of the earth and you will encounter very few meteors. Speaking of velocity, some showers produce meteors of greater velocity, and these produce better communications opportunities because they produce stronger ionization.

One more factor to consider is the distance between stations. The altitude at which meteor trails tend to form and the shape of the Earth define the reflection geometry such that the optimum distance for meteor scatter communications ranges from about 500 miles to about 1400 miles.

As you can see, trying to conduct meteor scatter communications when the shower is below the horizon; on, say, a north-south path when east-west is favored; at too great or too close a distance; or at sunset instead of sunrise will greatly reduce your chances of success.

References and Resources

That covers enough of the basics to give you an idea of what meteor scatter is all about and what resources are needed to participate. Admittedly it is a complex subject and anyone wanting to get involved will need to do a bit of reading and studying if they want to be successful. The complete text of this presentation, including several useful Internet links, can be found at ms.KR8L.us, and I believe that John has also provided a link to this from the club's Web site.

Print Reference

(Note that this provides historical information and was written well before the advent of digital techniques for meteor scatter.) The best print reference that I am aware of, not only for meteor scatter but for all the other long-distance weak signal modes that are used at VHF and UHF, is *Beyond Line of Sight, A History of VHF Propagation from the Pages of QST*, edited by Emil Pocock, W3EP, available directly from the ARRL and from many Amateur Radio publication vendors. (ARRL Order No. 4025, ISBN: 087259-402-5)

Internet References

The following references should prove useful, and a Google search will probably find many more.

WSJT Home Page

WSJT Download Page

K1JT's Autobiography

W8WN's Meteor Scatter Page

Ping Jockey Central

Original QST Article on WSJT

International Meteor Organization

Meteor Shower Table